Indian J. Phys. **72B** (2), 171-174 (1998)

IJP B
— an international journal

Association of large geomagnetic storms with solar flares during solar cycle 22

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Received 4 September 1997, accepted 4 February 1998

Abstract : The equatorial region large geomagnetic storms (Dst ≤ –100 nT) during 22nd solar cycle and their association with large solar flares have been studied. We find that the maximum number of large geomagnetic storms are associated with higher importance solar flares. It is also observed that the maximum number of large geomagnetic storms were produced by South-Eastern flares. The most effective heliographic zone for producing these storms has been mentioned.

Keywords : SIDs, SEPs, IP shocks

PACS Nos. : 92 60. Qx, 96.60. Rd

Geomagnetic disturbances are generally represented by geomagnetic storms, sudden ionospheric disturbances (SIDs) and ground-level enhancement (GLE). Geomagnetic storms can be distinguished into two kinds originated from two types of solar wind streams [1]. The first kind of geomagnetic storms, known as gradual commencement storms arise from magnetically open, long-lived high speed solar wind streams emitted by solar coronal holes and are usually small in magnitude and exhibit an apparent tendency to recur with 27-days rotation period of Sun [2]. The second kind of geomagnetic storms associated with flares generated streams, known as sudden commencement storms. These storms are relatively large in magnitude and are arising from the transient eruption of closed-field solar regions. The solar flare is a most spectacular short-lived phenomenon that occurs on the solar surface and is responsible for solar energetic particles (SEPs) events and geomagnetic storms. Solar flares transform magnetic energy into several forms. Large solar flares occur in magnetically complex region where the field is often strongly sheared. The mechanism of release of energy is associated with magnetic reconnection. There are two basic phenomena that occur during magnetic reconnection in the flare site. One of them is rapid heating of coronal and chromospheric material, which expands outward into the interplanetary medium and produces interplanetary (IP) shocks which cause geomagnetic storms and auroras. The other phenomenon is associated with particle acceleration, which represents the energy aspect of the flare. Number of workers

[3–5] have shown the association of different types of geomagnetic storms with solar flares and suggested that the solar flare of higher importance can produce large geomagnetic storms. In this paper, an attempt has been made to examine the association of large geomagnetic storms with solar flares of higher importance as well as occurrence of large geomagnetic storms within different heliolongitudional and heliolatitudional zones during 22nd solar cycle.

Transient, radiative and corpuscular emissions from the Sun associated with solar flares, produce outstanding disturbances in the environment of the Earth, which cause geomagnetic storms at various locations on the Earth such as polar, mid-latitude and equatorial regions. These geomagnetic storms are observed and represented by different geomagnetic indices AE, Kp and Ap and the equatorial Storm time index (Dst) value. In the present study, our selection criteria of geomagnetic storms are measured in terms of equatorial Dst value, which is a very sensitive index representing the degree of solar disturbances. The data of hourly Dst values and occurrence of solar flares were obtained from various volume of Solar Geophysical Data (SGD) bulletins.

In this communication, we have considered all those large geomagnetic storms, which are associated with the Dst decrease of more than 100 nT during the period 1986-1996. Out of selected 100 storms during the said period, it is found that 64% geomagnetic storms are associated with solar flares of importnace ≥ 1B. The association of large geomagnetic storms with importance of solar flares are displayed in the Figure 1. From this figure, it is observed that the maximum number of large geomagnetic storms are associated with solar flare of importance 1B, but we have not found any significant correlation between magnitude (intensity) of geomagnetic storm and importance of solar flare. Actually, solar flares of higher importance are able to produce IP shocks in interplanetary medium which causes the large geomagnetic storms The magnitude (intensity) of geomagnetic storms is associated with two kinds of IP shocks, known as fast and slow IP shocks. These fast and slow IP shocks are associated with different properties of solar flares *viz* time duration for flare emission, X-ray burst (mostly type-2 and type-4 radio burst) area, NOAA region, location (in heliographical latitude/longitude) and the shape of solar flares. In that case, sometime solar flares of lower importance which are associated with fast shocks, may produce more intense geomagnetic storms. So, we have not found any significant correlation between magnitude (intensity) of geomagnetic storms and importance of solar flares.

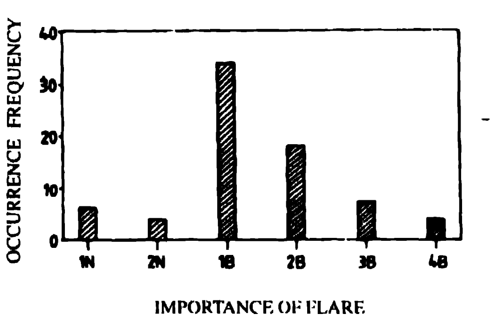

Figure 1. Occurrence of large geomagnetic storms with importance of solar flares.

We have also examined the association of large geomagnetic storms within different heliographic zones. A frequency occurrence histogram of large geomagnetic storms with different longitudional zones (East & West) is presented in Figure 2. We have found that 52% of large geomagnetic storms are produced by eastern flare and the longitudional zone between 0° E to 50° E is the most effective in producing large geomagnetic storms. At the heliolongitude

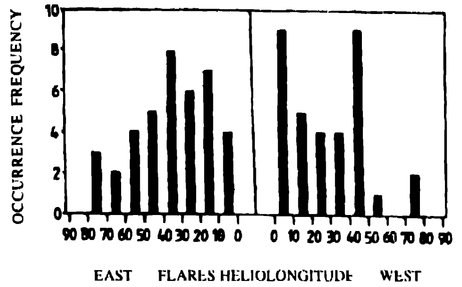

Figure 2. Occurrence of large geomagnetic storms with solar flares in different heliolongitudional zones

in the range 50° E and 50° W, 88% of the solar flare associated large geomagnetic storms are observed and remaining 12% are distributed over the range 80° E to 80° W. Similarly, Figure 3 shows the frequency occurrence histogram of large geomagnetic storms with various heliolatitudional zone (North & South). From this plot, we have found that the 63% of large geomagnetic storms are produced by southern flare and the most effective latitudional zone for

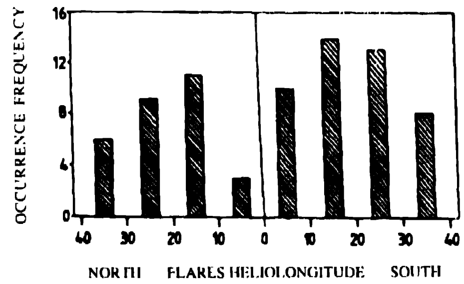

Figure 3. Occurrence of large geomagnetic storms with solar flares in different heliolongitudional zones

producing large geomagnetic storm lies between 0° S to 40°S. At the heliolatitude in the range 30° N to 30° S, there is a concentration of 82% of the flare associated large geomagnetic storms and no storm is produced by flares beyond 40° N to 40° S. So we conclude that the solar flares emitted within lower heliographical latitude and longitude, produce maximum number of large geomagnetic storms. The solar flares emitted within lower heliographic latitude and longitude are able to produce a strong configuration of closed magnetic field regions, which causes fast IP shocks in the interplanetary medium and large geomagnetic storms on the Earth. On the higher heliograhic latitude and longitude, solar flares do not produce fast IP shocks and only a few number of less intense geomagnetic storms are associated with these zones.

Acknowledgment

The authors would like to thank the referee for the valuable comments for improvement of this paper.

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